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*Original Article*

# Outcome of ligation of the persistently patent arterial duct in neonates performed by an outreach surgical team

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**Abstract** *Aim:* Our aim was to review the outcome of ligation of the persistently patent arterial duct in neonates as performed outside a paediatric cardiothoracic centre by an outreach surgical team. *Methods:* A retrospective observational study of all ligations of the persistently patent arterial duct performed in Cambridge between January, 1988, and December, 2002. *Results:* Over the period of 15 years studied, a persistently patent arterial duct was ligated in 43 neonates. The median gestational age at birth was 26 weeks, with a range from 23 to 35 weeks, and median weight at birth was 722 grams, with a range from 500 to 2100 grams. Median age at ligation, was 25 days, with a range from 10 to 89 days, and their weight was 963 grams, with a range from 568 to 2221 grams. Ligation was successful in 42 babies (98%), mortality at 30 days of 5%, and 29 of the babies (67%) surviving to be discharged from the hospital. The late deaths were due to complications of prematurity, rather than the procedure of ligation. *Conclusion:* The persistently patent arterial duct can successfully be ligated by an outreach surgical team outside a paediatric cardiothoracic centre. There was an excellent 30 day survival.

Keywords: Prematurity; neonatal intensive care unit; cardiothoracic centre

The haemodynamic consequences of a left-to-right shunt through a persistently patent arterial duct in preterm neonates may prolong the need for ventilatory support, and increase mortality and morbidity.[1] There are associations with chronic lung disease,[2] pulmonary haemorrhage,[3] intraventricular haemorrhage,[4] necrotising enterocolitis,[5] and retinopathy of prematurity.[6] Medical closure with inhibitors of prostaglandin synthetase, such as indomethacin, is usually the preferred treatment, and is often successful.[7] Surgical closure is mainly reserved for infants where medical treatment has failed or is contraindicated.[8,9]

In the United Kingdom, most ligations are conducted in paediatric cardiothoracic centres by paediatric cardiothoracic surgeons. Very few paediatric cardiothoracic centres are adjacent to neonatal intensive care units. Infants requiring ligation, therefore, may need to be transported over long distances, which may result in logistic problems in arranging transport and appropriate staffing. There may be difficulties in finding a paediatric cardiothoracic centre with capacity in both the intensive care unit and the operating rooms, thus delaying the surgical procedure, with potential compromise of the infant. To minimise these problems, some paediatric cardiothoracic centres advocate ligation as a day-case procedure.[10] In the United States of America, and Belgium, surgeons have performed the ligation on neonatal intensive care units as an outreach service with good results.[11,12] In our centre, two experienced cardiothoracic surgeons have ligated the duct with a liga-clip on the neonatal intensive care unit or operating theatre. Both surgeons work in an adult cardiothoracic surgical centre, one having had dual training in adult and paediatric cardiothoracic surgery, and the other having extensive

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experience of the procedure. They were supported by operating theatre staff, paediatric anaesthetists and neonatologists experienced in the peri-operative management of neonates. Our aim was to review the outcome of this process.

## Methods

Infants undergoing ligation of the patent arterial duct between January, 1988, and December, 2002, were identified from neonatal and paediatric cardiology databases, and a retrospective case note review was performed. Echocardiography was used to assess patency of the duct in the pre- and post-operative period. The scans were performed by neonatologists with special expertise in paediatric cardiology. Information collected included gestational age, birth weight, age and weight at ligation, prior use of indomethacin, and duration of ventilation before surgery. Postoperative data included duration of ventilation and requirement for oxygen, surgical and neonatal complications, and cause of death. Where babies had been transferred to another hospital for ongoing care, local paediatricians were contacted to provide follow-up data.

## Results

Over a period of 15 years, ducts were ligated in 43 babies. The demographic details are shown in the Table 1.

Of the babies, 31 (72%) had been treated with indomethacin before the surgery, with 38 babies intubated and ventilated at the time of ligation, and 5 receiving continuous positive airway pressure. Complete closure of the duct was confirmed by post-operative echocardiography in 42 (98%) cases. There were no immediate postoperative complications. There was one case of refractory chylothorax. Post-operative survival (Fig. 1) was 98% at the seventh day, 95% after 30 days, with 67% of the infants surviving to be discharged from the hospital.

The 14 deaths were due to mainly respiratory problems, and none were related to the surgical procedure. The median age of death was 80 days, with a range from 4 to 194 days, after the procedure. There were 2 deaths within 30 days of surgery. The first baby was born at 29 weeks gestation, weighing 1037 grams, and the ligation was performed on the fourteenth day of life. The postoperative echo confirmed residual patency of the duct. This baby could not be ventilated because of severe pulmonary interstitial emphysema, and died on the 18th day. The second baby was born at 28 weeks gestation weighing 943 grams. The ligation was performed on the 25th day. This infant died on the 42nd day due to chronic lung disease. The 12 later deaths were due to respiratory complications of prematurity, including chronic lung disease in 10 babies, aspiration in 1 baby, and bronchiolitis caused by respiratory syncytial virus in another. The cause of death was confirmed by post mortem in only one infant. In the other cases, consent for autopsy was not granted, and the cause of death was based on clinical diagnosis.

Of the 38 babies who had never been extubated prior to ligation, 36 were successfully extubated after a median of 5 days, with a range from 1 to 31 days. The duration of dependency on oxygen after surgery was 87 days, with a range from 22 to 469 days. More than half of babies no longer required oxygen at the age of 3 months (Fig. 2).

Table 1. Demographic details at birth and at the time of ligation.

| Characteristics | Median | Range |
|---|---|---|
| Birth gestation | 26 weeks | 23 to 35 weeks |
| Birth weight | 722 grams | 500 to 2100 grams |
| Age at ligation | 25 days | 10 to 89 days |
| Weight at ligation | 963 grams | 568 to 2221 grams |

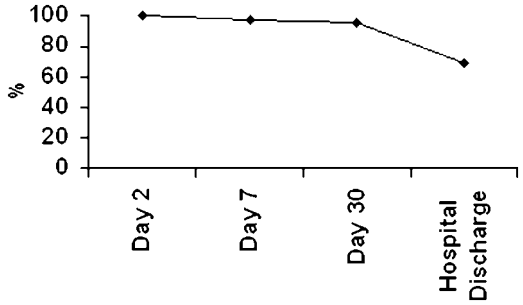


**Figure 1.**
*Post-operative survival after ligation of the patent arterial duct.*

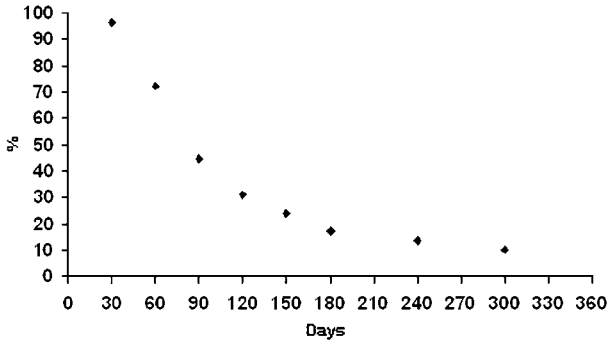


**Figure 2.**
*Duration of dependency on oxygen in survivors after ligation of the patent arterial duct.*

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Of the 29 survivors, 26 (90%) had chronic lung disease defined as dependency on oxygen at 36 weeks post-conceptional age, 18 (62%) had retinopathy of prematurity, 14 (48%) had either proven or suspected necrotising enterocolitis, and 10 (34%) had intraventricular haemorrhage.

## Discussion

The results of our study show that persistently patent arterial ducts can safely be ligated outside a paediatric cardiothoracic centre by surgeons trained in the procedure. The mortality of 5% at 30 days is comparable with the rates reported in previous studies.[8,12] There was a high late rate of death in our babies compared with other series.[9,10] These late deaths were due to the complications of prematurity rather than the surgical procedure. The higher mortality in this population may reflect better long term follow-up of these high risk neonates.

Previous studies have shown acceptable results for ligation when performed on neonatal intensive care units.[11,12] Gould et al[11] found no difference in the morbidity and mortality between the onsite and offsite ligation in two groups of neonates. In our experience, there are several advantages of performing ligation on the neonatal intensive care unit, or in the base hospital by an outreach surgeon supported by local staff experienced in the peri-operative management of neonates. It avoids transporting a critically ill neonate to a distant paediatric cardiothoracic centre. Post-operative management can immediately be returned to the neonatologists who are familiar with the infant, achieving optimal continuity of care. Ligation on the neonatal intensive care unit also avoids additional parental anxiety, which may be associated with the transfer of their baby to the unfamiliar surroundings of a paediatric cardiothoracic centre. When analysing the cost of equipment, staff, and length of stay, it has been shown that it is cost effective to perform the procedure on the neonatal intensive care unit.[13] Scheduling surgery is simpler, and it is less likely to be delayed, as it requires liaison with only the surgeon, rather than awaiting a bed space and a surgical slot in the paediatric cardiothoracic centre, which is often the rate-limiting step. Ligation as a day case in a paediatric cardiothoracic centre has been suggested as an alternative to surgery in the neonatal intensive care unit.[10] This still requires coordination of transport and potential delays until the baby is stable enough to tolerate the return journey as well as the procedure.

We acknowledge that there are potential disadvantages of performing the ligation outside a paediatric cardiothoracic centre. If there is a major surgical complication, there will be no access to cardiopulmonary bypass. Given the size of these neonates, further surgery on bypass may not be an option. There are also potential clinical governance issues. The recommendation of the Bristol enquiry,[14] and the Report of the Paediatric and Congenital Cardiac Services Review Group,[15] were that cardiac surgery should be undertaken in specialist centres by surgeons who undertake a minimum number of procedures.

With the centralisation of paediatric cardiac surgery, the outreach service in Cambridge was discontinued in 2002. Since then, 4 neonates have been referred to paediatric cardiothoracic centres for ligation. These babies had a mean gestational age at birth of 24 weeks, and weighed 589 grams. All received at least 2 courses of indomethacin, and remained ventilator-dependent with persistent patency of the arterial duct. In each case, it was difficult to arrange ligation, with 2 to 3 cardiothoracic centres contacted, with delays of between 10 and 18 days before the procedure could be performed. Fortunately, these delays did not result in adverse outcomes. If all ligations are to be performed in paediatric cardiothoracic centres, issues of capacity will need to be addressed. An outreach service conducted in selected specialist neonatal surgical units could alleviate some of the pressures on the cardiothoracic centres. Outreach ligation could be performed in neonatal units where there is experience in the peri-operative management of neonates, and there is local cardiac expertise. This procedure could not be carried out in every neonatal unit.

In conclusion, our study confirms that persistent patent arterial ducts can safely be ligated outside paediatric cardiothoracic centres by trained surgeons supported by staff experienced in neonatal surgery. Whilst it may no longer be appropriate for a trained adult cardiothoracic or general paediatric surgeon to perform ligations, it may be in the best interest of the infant for an experienced paediatric cardiothoracic surgeon to travel and offer an outreach service, where distances allow. Long term follow-up of this high risk population is also required.

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